J. Pure Appl. & Ind. Phys. Vol.3 (3), 225-228 (2013)

Use of Laser in Environmental Studies

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(Received on: June 23, 2013)

ABSTRACT

Lasers are widely used for fundamental studies not only in the areas of core physics, but also almost all its related disciplines, like engineering, chemistry, life and medical sciences. In spite of these studies, laser is also being used in monitoring the environmental conditions in various places on the basis of laser-aided measurements of the atmospheric pollutants to generate a data base. The data base will be useful in predicting the atmospheric conditions in desired time interval in and around the particular place to warn people from natural disaster.

Keywords: Laser, Radioactive pollutants, LIDAR, Radar, Raman shift.

1. INTRODUCTION

The advent of laser, like other celebrated devices invented over the past one hundred odd years,[1] has ushered in a surge of activity not only in the areas of core physics, but also almost all its related disciplines, like engineering, chemistry, and life and medical sciences[2]. And of late, laser is also being used in the up developing fields of environmental physics and environmental chemistry, which constitute, in major parts, what is known as environmental sciences today[2].

It is indeed well known that laser has two unique properties,

(i) Directionality and
(ii) Mono chromaticity

These two properties of laser are successfully made use of in the ambient assessment of concentration of various atmospheric pollutants.

2. VARIETY OF ATMOSPHERIC POLLUTANTS

The major pollutants in the atmosphere among others are the following:

(i) Oxides of sulphur (SO_2), especially sulphur dioxide (SO_2)
(ii) Oxide of Nitrogen (NO_2), say, for example, Nitrogen dioxide (NO_2);
(iii) Poisonous Carbon monoxide (CO), and the green house gas carbon dioxide (CO_2);
(iv) Volatile organic Component (VOC) such as hydrocarbon fuel vapours and solvents;
(v) Radioactive pollutants produced by nuclear explosion and war explosives as well as natural processes such as radon; and also a variety of other particulate matters, such as dust, smokes and fly ash.

3. METHODS OF LASER-MONITORING

The basic method of laser monitoring consists in sending a beam of laser radiation through the sample of atmosphere to be investigated and then monitoring either the transmission or the scattering of the light. According to the monitoring techniques employed, there exist quite a few versions of the laser-assisted pollution control. Here we take up the following three of those versions most widely used.

3.1 The optical Radar Method

This method depends on light scattering from the pollutants in the atmosphere. The optical Radar techniques used for this purpose are often called LIDAR, an acronym for Light Detection and Ranging[3].

LIDAR works in a manner similar to Radar. In its basic form, LIDAR employs a pulsed laser simply as a source of light energy. The light that is back scattered is then detected by a photo detector. The distance of the point of scattering congestion of the particulate matter from the point of shooting is calculated by noting the total time which the shot light pulse takes in going to the congestion point and coming back from there to the shooting point. This process is similar in manner to that of a Radar ranging system.

Hence, LIDAR is very useful in determining concentration of a particulate matter as a whole, but it does not give any information about the nature and composition of the scattering particles. Indeed, the LIDAR system has been used most often in the cases where the total concentration of particulate matter is desired. The LIDAR system has the capability of determining the said concentration as a function of the distance from the measuring station. Thus this helps to provide the distributions of atmospheric pollutants in different vertical sections, and monitor the variations with the vertical profiles.

3.2 The Absorption Method

These techniques are extremely sensitive and hence useful in the detection of specific gases in the atmospheric sample.
The usual procedure here is to transmit the laser beam through the sample to be studied. The attenuations of the intensity of the transmitted light due to the absorption in the sample is then recorded with a detector placed on the other side[3].

In this connection, there is something called the chemical revolving power in the technique of the method. This relies on the well known fact that each chemical compound absorbs light at characteristic wavelengths and hence can be detected by measuring the atmospheric transmittance. As an example, a frequency doubled dye laser can be used by operating it at 0.372 μm in order to detect the atmospheric Methane (CH_4). The same laser may be used to detect the lower oxide of nitrogen, say, the nitrous oxide (NO), but by operating it at 0.389 μm. In both the cases, the sending range extends for a few hundred meters.

3.3 The Raman Back Scattering Method

The Raman Effect phenomenon in gases consists in scattering of light by molecules of gases accompanied by a shift in the wavelength of the light. And, for a particular gas according to the quantum theory of this phenomenon, this is appearance of additional spectral lines near by the original wavelength[3]. Indeed, the Raman effect phenomenon occurs because of the fact that the atoms in a molecule oscillates in a number of frequencies, and when a beam of monochromatic light is incident on a sample of molecules of a gas, the output light will also contain two side bands shifted from the original light frequency on either side by a frequency equal to the molecular oscillation frequency of the molecule of the sample itself, the said shift being called the Raman shift. Since the Raman shift is characteristic of a particular molecular species, the analysis of the back scattered laser light immediately reveals the constituents of the sample of gas by their characteristic shifts. As an example, for the detection of sulphur anhydride (SO_2) at a place, the atmospheric volume of interest at the place is to be scanned by the frequency doubled ruby laser light at 0.347 μm[4].

There is no restriction on the frequency of the laser light used in this technique. Nevertheless, the Raman back scattered radiation appreciably increases when the original frequency is near the resonant absorption of the particular molecular species. Hence, tunable lasers will be of great use for application in this case. It is possible to achieve relative increase in intensity to even several orders of magnitude by the use of such tunable lasers[4].

4. ADVANTAGE OF LASER OVER CHEMICAL METHODS

The conventional techniques of pollution control consists in the chemical analysis of a previously collected sample of air. These techniques evidently cannot give a real-time data base, and moreover, some of them are even incompatible with automatic measurements at fixed locations[4].

The laser techniques, on the other hand, perform these measurements by sensing the composition of the atmosphere from a remote point, simply by sending a light beam without the need of collection of any sample of air and without any chemical processing. The results of such measurements are available immediately and there is no distortion, whatsoever, of the quantities being measured. Thus, these laser-based techniques provide us with the real-time data and are hence extremely suitable for drawing the time-variations of the atmospheric conditions in terms of Pollutant

contents. This is extremely useful for monitoring the environmental matrix, that is the environmental conditions in the region of the space.

5. CONCLUSION

Laser can be used more extensively and exhaustively in monitoring the environmental matrices (environmental conditions) in various places, like the cities, towns and industrial localities. The purpose here is to generate a data base on the basis of such laser-aided measurements of the atmospheric pollutants at these places on a real-time scale. The generated data base will be extremely useful in predicting the atmospheric conditions to come into existence at any desired future time with reasonable accuracy. Thus it would be of great utility to the people at large in and around the particular place.

REFERENCES

1. B.B. Laud, Lasers and Non-linear optics, Wiley Eastern Ltd. (1985).
2. L. Tarasov, *Laser Physics and applications*, MIR, (1986).
3. Eugene D. Olsen, Modern optical Methods of Analysis, Me Graw Hill Book Company, pp. 487-578 (1975).
4. A.K. Das, Bulletin of IAPT, No. 2-3 pp. 49-50, Feb.-Mar (2009).